Chemical Weathering Soil Profiles of the Rio Chagres Watershed

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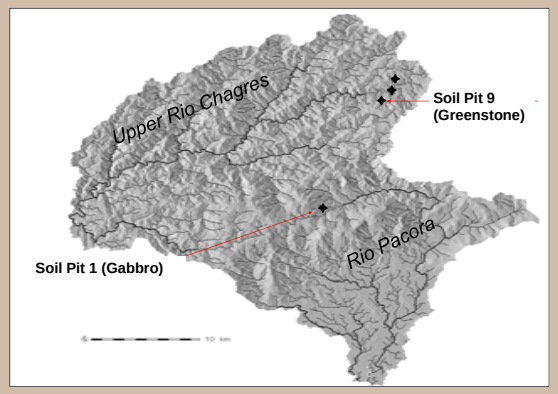
1. Abstract

Chemical weathering is a major process in the development and resultant bulk chemistry of soils, yet little research has been done in moist tropical climates investigating the relationship between the chemistry of soil and extent of weathering as related to depth. For this research project, two sample soil pits were dug in the Rio Chagres watershed in central Panama, and 13 samples from each soil pit were collected at approximately 12 cm increments from surface to close to bedrock. The soil pits were located directly above a gabbro and a greenstone, two of the dominant lithologies of the basin. Analysis for this research project was done by grain size and carbon and nitrogen analysis, and by use of X-ray fluorescence spectrometry (XRF) to measure major and trace elements present. Calculation of the Chemical Index of Alteration (CIA) and Vogt's index of weathering (V) were also completed to evaluate degree of weathering as related to depth to establish an accurate weathering profile for each pit. In Pit 1, located above the gabbro, grain size decreases and weathering index increases with depth, suggesting a greater influence of subsurface groundwater during weathering. In pit 9, located above the greenstone, grain size fluctuates with depth and is overall more course than of pit 1, and the weathering index is highest at the surface and decreases with depth. This represents a more traditional and expected weathering profile, with the greatest weathering occurring at the surface. Future research is needed to provide a more continuous data set as well as information on trace element behavior in these profiles.

2. Study Site Geology

Central Panama (approx. 9ºN latitude) is composed of a unique complex of relatively young intrusive and extrusive island arc volcanics, metamorphic, volcaniclastic and shallow marine sedimentary rocks. The Rio Chagres basin, where samples for this project were collected, has lithologies of primarily greenstone, andesite and gabbro of Tertiary age. The Rio Chagres basin is an extensive watershed and the main supplier of water to the Panama Canal. As much as 3 meters of rain a year will fall in the Chagres basin, and the mean annual temperature of the region reaches 18ºC and higher. The warm and humid tropical climate facilitates rapid chemical weathering, leaving deep, clay rich soils that conceal the underlying bedrock and host dense tropical vegetation at the surface. It is important to note as well that the soil pits sampled for this research project are located on different geomorphological features. Pit 1 is located at the top of a ridge crest and Pit 9 is located in a basin near a stream.



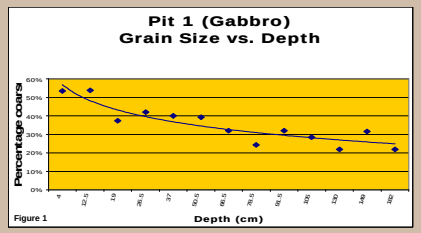
Upper Rio Chagres and Rio Pacora Watersheds, Central Panama

3. Methods

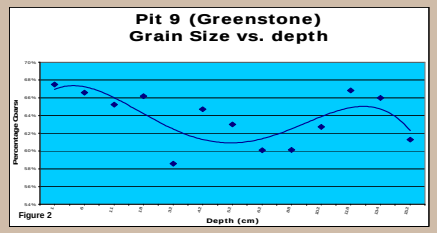
Wet soil samples were placed in aluminum dishes and dried by air for several days. Dry samples were weighed, sieved to determine particle size percentages, and then the separate components were added back together. A small amount of sample was set aside for carbon and nitrogen analysis, and the rest was crushed in a shatterbox for a period of 8 to 11 minutes. The product was stored in a drying oven or desiccator until ready to use. To make the major element beads for the XRF process, sample and Lithium Tetraborate flux were added together in a 1:10 ratio, mixed, melted and cooled to form homogenous glass beads. For the trace element beads, 12.000g of sample was combined with 3.000g of Briquetting additive and pressed into a round bead with 25 tons of force. These beads were analyzed by use of X-ray fluorescence method to evaluate the trace and major element concentrations. Concentrations were used to calculate V (Vogt's Residual Index) which represents the degree of weathering the sample has undergone.

Vogt's Residual Index (V)= $\frac{(Al2O3 + K2O)}{(MgO+CaO+Na2O)}$

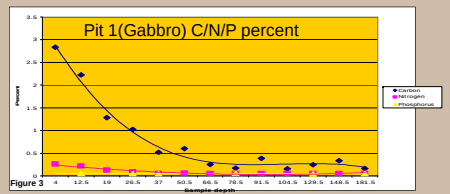
4. Results

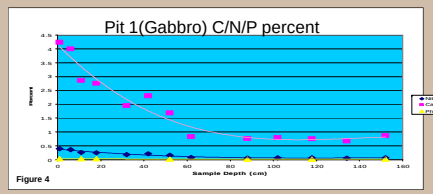


•Grain size decreases with depth, indicating a higher degree of weathering trending downwards



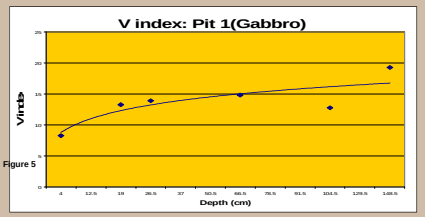
•Grain size shows no true trend as related to depth





•Carbon and Nitrogen decrease with depth, showing rapid weathering of these elements

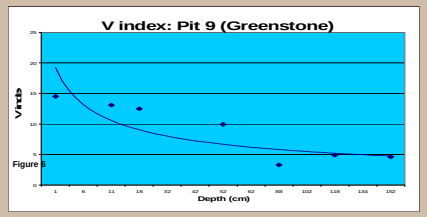
•Phosphorus stays relatively the same, indicating immobility



•Values of V increases with depth indicating a higher degree of weathering trending downwards

•Surface soils are less weathered than deep soils

•Possible cause of this weathering profile could be due to deep soil interaction with groundwater



•Values of V decrease with depth indicating a higher degree of weathering trending upwards

•Soils are more weathered at the surface

•Shallow weathering profile overall

5. Discussion

Harrison et al. (2005) has demonstrated that soils on upper slopes, like those of pit 1, are weathered more than soils on lower slopes, like those of pit 9. Figure 5 shows that pit 1 has higher V values overall, indicating a high degree of weathering. The V values for pit 1 also increase with depth, showing an increase of weathering at depth. The soil is strongly developed and deeply weathered. Pit 9, which is located at a lower elevation near a stream, shows a less developed and shallower weathering profile in figure 6. Pit 9 is weathered only to a shallow depth. The higher percentage of coarse components of soils from pit 9 also indicate less weathering. My data supports previous soil descriptions related to basin vs. ridge crest locations and their weathering patterns discusssed by Harrison et al. (2005)

6. Conclusions

•C and N decrease consistently and dramatically with depth for both sample sites, indicating rapid organic matter decomposition

•P remains relatively consistent with depth which suggests immobility during weathering

•Weathering indices and grain size analysis indicate that Pit 1 is highly weathered at depth while pit 9 indicates more shallow, less severe weathering.

• These results agree with previous soil studies of Harrison and others.

7. Future Work

•More samples from each series are to be evaluated to provide a complete profile for each sample site

•Trace element analysis via XRF to determine other elemental behavior in these tropical soils

•Analysis of felsic bedrock derived soils from the Rio Chagres region to compare mafic vs. felsic weathering rates and profiles for the region

References

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